

Fig 2

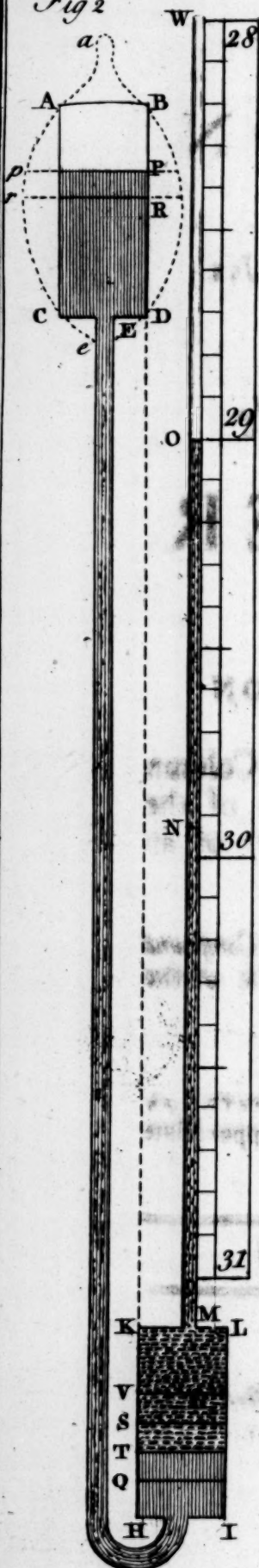
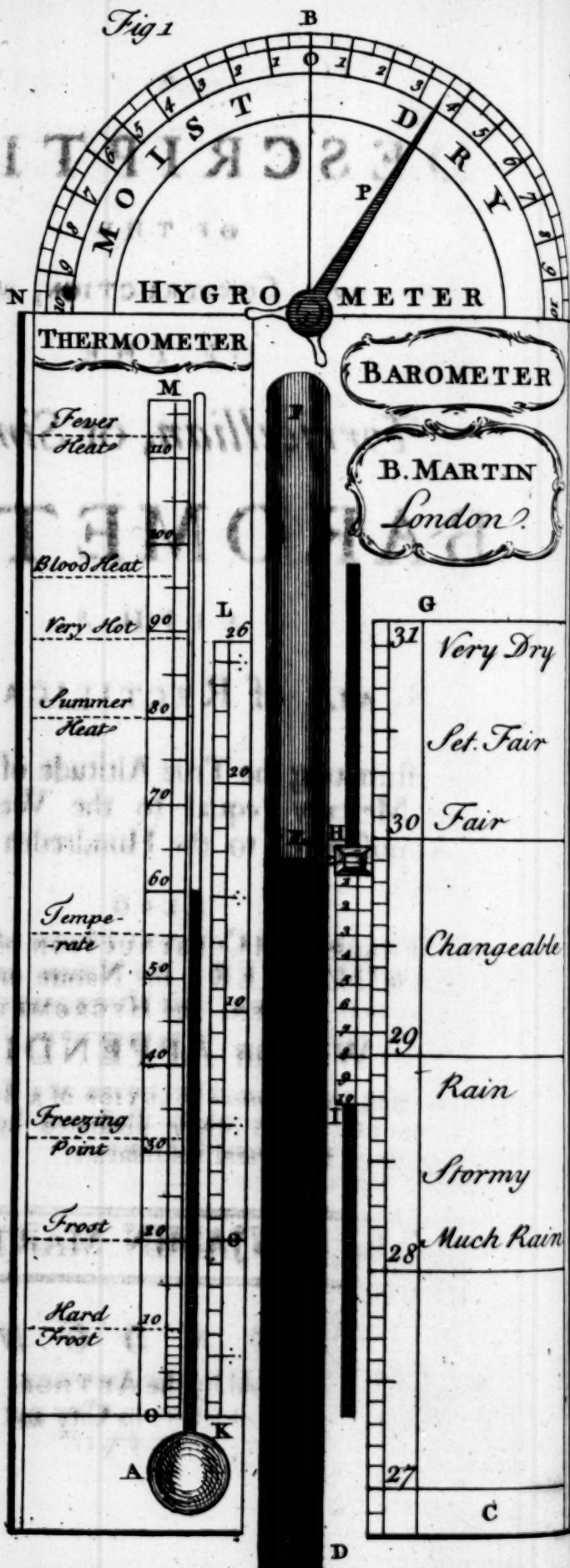
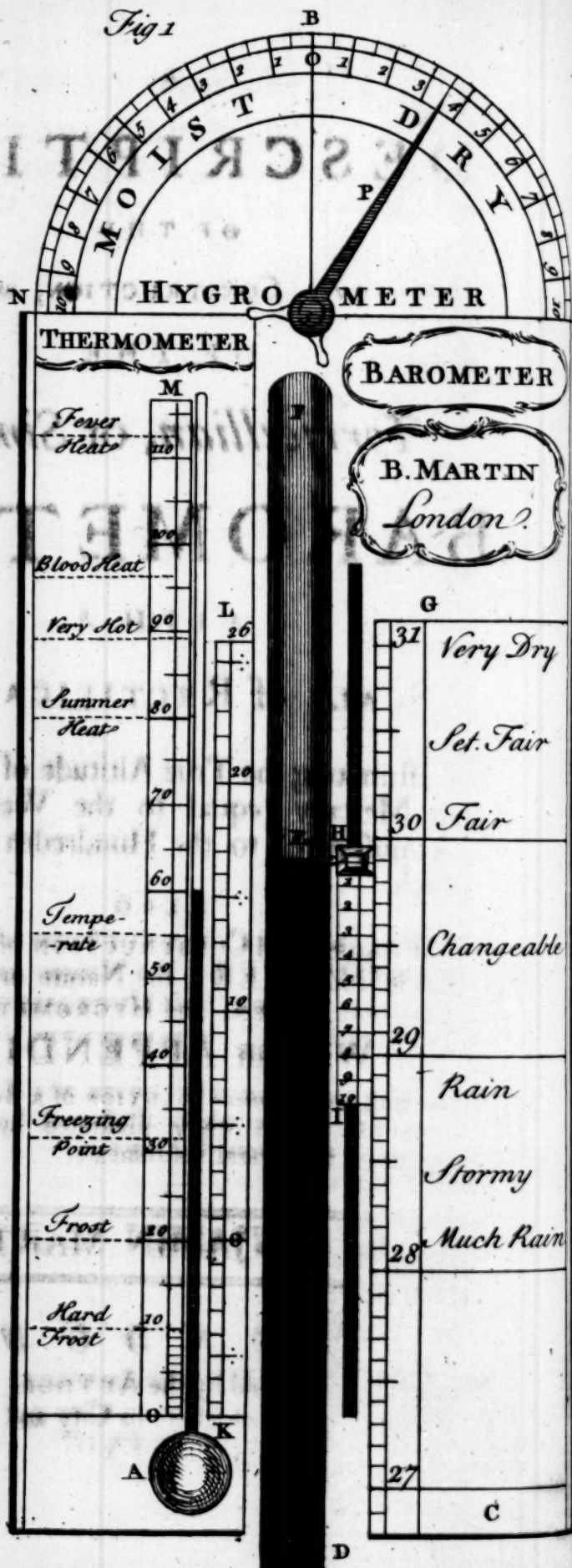
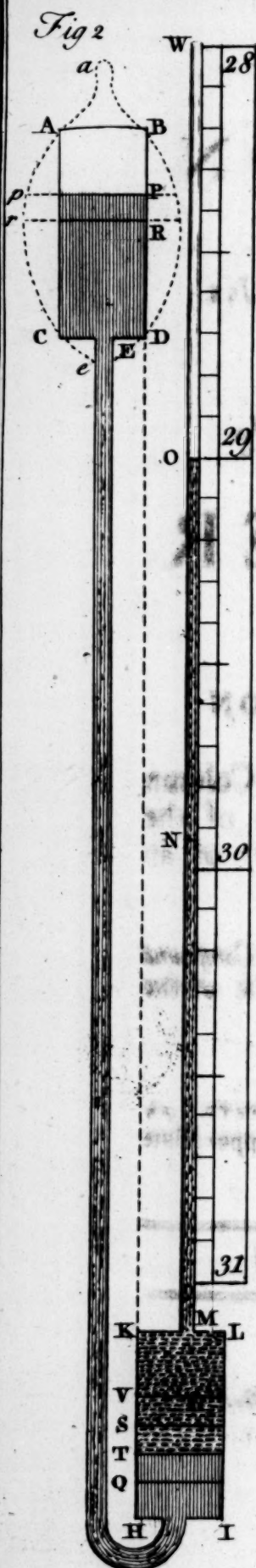


Fig 1





(3)

A
DESCRIPTION
OF THE
NATURE, CONSTRUCTION, and Use
OF THE
Torricellian, or Simple
BAROMETER.

WITH A
SCALE OF RECTIFICATION

For estimating the True Altitude of the Column
of Mercury (equal to the Weight of the
Atmosphere) to the Hundredth Part of an
Inch.

ALSO

The THEORY and CONSTRUCTION of the *Compound*
BAROMETER; the Nature and Use of the
THERMOMETER, and HYGROMETER.

With an APPENDIX,

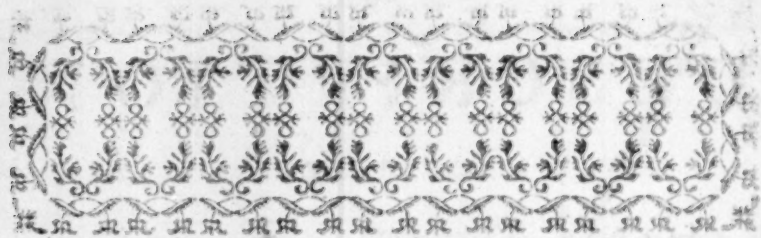
Containing an *Analytical* SOLUTION of a BAROMETRICAL
PROBLEM. The whole illustrated by Copper-Plate
Figures of the several Instruments.

By BENJAMIN MARTIN.

L O N D O N:

Printed for, and Sold by the AUTHOR, in *Fleet-street*,
and by the Booksellers in City and Country.

M DCC LXVI.



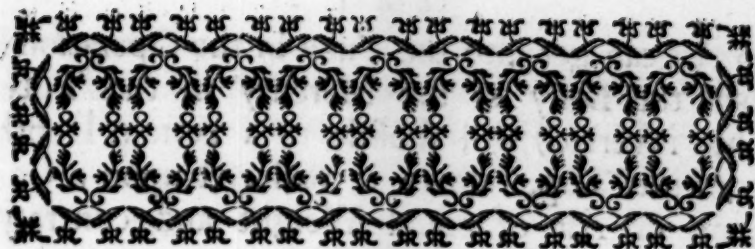
A DESCRIPTION of the NATURE,
CONSTRUCTION, and Use of the
Toricellian BAROMETER
Testified for Philosophical En-
QUIRIES.

THE Instrument we call a BAROMETER, both in Regard of Curiosity and Utility, has always been esteem'd the first in Dignity among the modern Philosophical Inventions. The Use of it, is, as it's Name imports, to measure the Weight of the Air at all Times, and to indicate continually and momentarily it's Variations and Changes in that Respect.

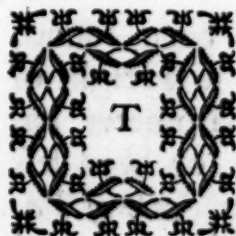
The Weight of the Air is the most important Principle in Nature, and tho' it is capable of being demonstrated many Ways, yet there is none so direct, easy, and natural, as that of the BAROMETER, which will evidently appear from the very Description of it.

A BAROMETER of the most simple Form consists of a strict Glass Tube hermetically closed at one End, and being filled with Mercury, is inverted with the open End into a Basin of the same Fluid, in such a Manner that

A



A DESCRIPTION *of the* NATURE,
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Torricellian BAROMETER
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A BAROMETER of the most simple Form, consists of a strait Glass Tube hermetically closed at one End, and being filled with Mercury, is inverted with the open End into a Basin of the same Fluid, in such a Manner that

no Air can get into the Tube in the Operation; then the Body of the Mercury in the Tube (thus inverted) will subside to a certain Depth from the Top, where it will rest upon a Column of Air of equal Weight and contrary Pressure.

By this Definition of a Barometer, it appears that since the Column of Quicksilver in the Tube is sustained by, and depends wholly on an equal and contrary Pressure of the Atmosphere, the Altitude of that Column of Mercury in the Tube must necessarily be an *adequate Measure* of the Weight or pressure of the Air upon the same Orifice or Area of the Bore of the Tube.

By constant Experience it has been found, that in our Climate, or Island, the Height of this Column of Mercury in the Barometer has never exceeded thirty one Inches, or been less than twenty-eight. Therefore the *Scale of Variation* is three Inches, which is about a *tenth Part* of the whole Height. This Scale of three Inches is placed with its lowest Part just twenty-eight Inches from the Surface of the Mercury in the Basen at the Bottom of the Frame.

In order to shew that a Barometer constructed in this Manner, is the *only One* that will admit of *Perfection*, or go at all Times *precisely true*, it will be necessary to represent the upper Part thereof as in Fig. 1. But because a Barometer will be inevitably deficient in a small Degree without a THERMOMETER (as we shall shew by-and-by) therefore these two Instruments are necessary Companions, and ought always to be placed by each other, in a Frame. To these I add

add a third, which is a very useful Instrument, called a *HYGROMETER*, and so make a *triple Weather Glass* for answering every Purpose.

These three Instruments are shewn in Plate I, Figure I. Where A B C is an engraved Brass, Ivory or Silver Plate, in which they are all contained, with their proper Scales. In the Middle Part of this Plate is cut a long Slit fit to receive and contain the upper Part of the Barometer Tube D E F, in which the Top of the Column of Mercury appears at E; all the Space above to the Top at F, being void of Air.

On the Right-hand Side of the Tube D F is the Scale of four Inches C G, viz. from twenty-seven to thirty-one, and the Number twenty-seven, is just twenty-seven Inches from the Surface of Quicksilver in the Basin below. Hence as the Surface of the Mercury at E rises and falls with the Variation of the Air's Gravity, that will be denoted, and its Height measured, by an Index at H, which Slides up and down, in a proper Groove, and is fixed to any Part, as occasion requires.

The Altitude of the Mercury is measured by a simple Index only, in Inches and Tenths of an Inch, which for all common Uses is sufficient to indicate the general Alterations in the Weight of the Air, and, of Course, the Changes of Weather.

But those who chuse to be more accurate, and are curious in physical Researches, may have this *Scale of Variation* still more minutely divided by a little moveable Slip of Brass H I, containing ten equal Parts or Divisions, which together are just equal to eleven of those on the Scale of Variation, that is, to eleven Tenths of an Inch.

By

By this Artifice the Height of the Mercury at E is evident, by Inspection only, to the $\frac{1}{100}$ (*hundredth Part*) of an Inch. That this may be understood, nothing more is necessary than to consider, that *one Tenth Part of a Tenth of an Inch*, is the *one hundredth Part of an Inch*. Now every Tenth of an Inch in the Scale C G is divided into ten equal Parts, by the Slip (called a *Nonius*) H I; for since ten Divisions on that exceeds ten on the Scale by one Division, that is, by one tenth of an Inch, therefore one Division on the *Nonius* will exceed one Division on the Scale by *one Tenth Part*; and two Divisions on the *Nonius* will exceed two on the Scale by *two Tenths*, and so on: Therefore every Division on the *Nonius* will exceed the same Number of Divisions on the Scale by *so many Tenths of a Tenth*, or by *so many Hundredth Parts of an Inch*.

Therefore when the *Nonius* is used, the ten equal Divisions of an Inch on the Scale C G, must be looked upon as so many *Ten Hundredth Parts of an Inch* and numbered thus, 10, 20, 30, 40, &c. Parts of an Inch, then the *Nonius* gives the Units to each ten, thus; set the Index H very nicely to the Top of the Surface of the Mercury E, and if at the same time the Beginning of the Divisions at H coincides with a Line of Division in the Scale C G, then it shews the Altitude of the Mercury in Inches and Tenths of an Inch exactly.

But suppose the Index Line H of the *Nonius* falls between two Divisions or Tenths on the Scale C G, then there will be a Coincidence of Lines in both at that Number of the *Nonius* which shews how many Tenth Parts of that Tenth the
Index

Index of the *Nonius* has passed the last decimal Division of the Scale : Thus for Example, suppose the Index of the *Nonius* were to point somewhere between the 8th and 9th Tenth, above 29 on the Scale, then if by looking down the *Nonius* you observe the Coincidence at Number 7, it shews that the Altitude of the Mercury is 30 Inches and 7 Parts of a Hundred of another Inch.

Where such great Precision is required several Circumstances must be attended to, which in common Use are not so very material ; as (1.) A Tube with a large Bore, 3 or 4 Tenths of an Inch Diameter, that the Surface of the Mercury in the Tube may be nearly *Plane*, and not sensibly *convex*, as in those of a smaller Size. (2.) That a *Magnifying Glass* be applied in setting the Index of the *Nonius* most accurately to the Edge of the Surface of Mercury. (3.) That the Surface of the Mercury in the Bason below be so large that its Altitude may not sensibly vary with that of the Mercury in the Tube. (4.) That the Error the Barometer is liable to from *Heat* and *Cold*, be well corrected.

These two last Article merit a more particular Consideration, as upon them the great Perfection of this Instrument depends. As in this simple Barometer the Scale of Variation is near three Inches, it is therefore to be supposed, that these three Inches of Mercury in the Tube may all go into the Bason at Bottom without any sensible Elevation of its Surface, and this we may reckon about the *Hundredth Part of an Inch*.

Therefore if the Diameter of the Tube be given, you find the Diameter of the Bason of a Cylindric Form,

Form, such that three Inches of Mercury in the given Tube shall make a Rise of only $\frac{1}{100}$ of an Inch in the Basen, by this Rule — *Multiply the Square of the Diameter of the Tube by 300; then the Square Root of that Product will be the Diameter of the Basen required.*

For Example, let the Diameter of the Tube be $\frac{2}{10}$ of an Inch, the Square thereof is $\frac{4}{100}$, which multiplied by 300 gives 12, the Square Root of which is 3,46 or $3\frac{1}{2}$ Inches nearly, for the Diameter of the Basen required. By this Rule, a Tube of $\frac{3}{10}$ of an Inch, will require a Basen near $5\frac{1}{2}$ Inches Diameter; and a Tube of $\frac{4}{10}$, will have a Basen 7 Inches Diameter nearly.

Indeed, as there scarce ever go 3 Inches of Mercury out of the Tube into the Basen, we may take $2\frac{1}{2}$ at a Mean; and instead of 300, multiply by 250; the Diameter of the Basen will be large enough for Use, even to the most curious.

The fourth Article mentioned as requiring the Attention of the *Virtuoso*, is the Error that arises from the Alteration of the Bulk of Quick-silver by Heat and Cold; every one knows that all Bodies, Solid or Fluid, have their Bulks encreased by Heat, and lessened by Cold; and consequently their Specific Gravities will decrease and encrease proportionably at the same time, and from the same Causes.

Hence it follows that a Column of Mercury 28 or 31 Inches high, is not so heavy in very hot Weather, as it is in very cold Weather. Since then a Column of Mercury of the same Height has a different Weight in different Temperatures of Weather, it may in these different

ferent States of Weather indicate the same Weight of the Atmosphere, though the real Weight be variable all the While. For Example, the Air is considerably lighter when the Mercury stands at 30 Inches in hot Weather than it is when the Mercury has the same Height in Weather that is very cold.

Hence it appears that in order to correct the Altitudes of Mercury in the Barometer, it will be necessary to know in what Ratio Mercury expands in a given Degree of Heat. This we have determined to our Hands by the Experiments of the celebrated Mr. AMONTONS, who found that a Column of Mercury of 115 Lines in great Cold extended to 116 Lines with great Heat; and because 12 Lines make a *French* Inch, therefore 3 times 115 Lines is 28 Inches 9 Lines; and 3 times 116 is 29 Inches, and consequently in 29 Inches, there was an Extension of 3 Lines.

These two Extremes of Cold and Heat in his Thermometer were at 50 and 58, which in *Fahrenheit's* answer to 20 and 88. And since the Proportion of the *French* Foot is to the *English* Foot as 128 to 120, therefore 29 *French* Inches is near equal to 31 of ours. Hence then, as 29 *French* Inches contain 348 Lines, and 31 *English* Inches contain 310 Tenths of an Inch; if we say, as 348 is to 310, so is 3 Lines to 2,7 Tenths of an Inch *English*; this last Number will be the Extension of a Column of Mercury 30 $\frac{27}{100}$ Inches high.

If then we take 29 $\frac{1}{2}$ Inches Height of Mercury for the Mean Weight of the Air, and say as 310 is to 27, so is 295 to 26 nearly; it will appear that the Mean Variation of the Column of

B

Mercury

Mercury from the Cold of 20 Degrees to the Heat of 88 in *Farenheit's* THERMOMETER is 26 Hundredth Parts of an Inch.

Consequently if a Scale of 26 equal *Parts*, equal in Length to the Distance between those two Points of 20 and 88 Degrees, and placed by the Thermometer in a corresponding Position, it will always appear by Inspection of the Thermometer how many of those 26 hundred Parts of an Inch are to be deducted from the present Height of the Mercury in the Barometer, to have the *true Height*, or that which is owing to the *Weight of the Air alone*.

This Correction of the Barometer is in a Mean Degree, 'tis true, but it is so very near the Truth, that the most scrupulous Enquirer into Nature cannot well complain of it's Deficiency; especially if it be considered that the Altitude of the Mercury is mostly between 29 and 30; and, of Course, where there can be no sensible Error at all.

However to exempt the *simple Barometer* from all Imputation of Error, nothing more is necessary than an easy Operation by the *Rule of Three*; for suppose the Index of the *Nonius* gives the Height of the Mercury 29,37; and the Thermometer stands at 63, then in the Scale against 63 is $16\frac{1}{2}$ Hundredths of an Inch, to be deducted from the present Altitude 29,37; which will give 29,205 for the Altitude near the Truth, by the *Scale alone*.

But to have the Altitude precisely true, these $16\frac{1}{2}$ Hundredths of an Inch must be added to the greatest Altitude 30,73, which will give 30,895 for the greatest Altitude the Mercury could have with the present Degree of Heat 63.
Then

Then since the Expansions are as the Altitudes of the mercurial Columns, we shall have, by the Rule of Three, this Analogy, as the greatest Altitude (with the present Heat) 30,895 is to the present Altitude 29,37, so is the Expansion 16,5 for the greatest Altitude to the Expansion 15,686 due to the present Altitude, which being deducted from 29,37 leaves the true Altitude 29,213, which is but $\frac{8}{1000}$ of an Inch more than before.

From hence it appears, that the Errors of the simple Barometer are to be corrected without any Trouble, even as it were by the Glance of the Eye : But this will be rendered still more intelligible by Fig. 1. wherein A M is *Farenheit's Thermometer*, with it's proper *Scale of Degrees of Heat* ; and K L the *Scale of Rectification* for the *Barometer*, containing the 26 Hundredths of an Inch, as above determined, and which begins from the 20th Degree. And thus the whole Matter is comprised and represented in one simultaneous View.

But one Thing is to be observed, *viz.* that the *Rarefaction of the Mercury* has been hitherto only considered, above the *standard Density* which it has at the 20th Degree of the Thermometer, and when the Altitude thereof in the Barometer does justly indicate and measure the true Weight of the Air. But since in all Degrees of Cold below 20, the Density of the Mercury will be greater than the standard Density at 20, therefore the Columns of Mercury in all such Degrees of Cold will be too short to measure the true Weight of the Air ; and consequently will require an *Addition* of so many of those 26 Hundredth Parts as correspond to

the Height of the Thermometer. But it is a hard Frost at 20 Degrees, therefore it will rarely happen that the Column of Mercury will be too dense or heavy; and consequently a few of these additional Parts will suffice.

From this Account of the Nature of a *Barometer* it is evident, that which is here specified has the following peculiar Advantages, *viz.*

First, It is the most *simple, compendious, and facile Construction* that such an Instrument is capable of; there is only one strait glass Tube, and one Fluid only, and there cannot be less of either. Also it is filled, and placed in a proper Manner, without any Trouble, and in a few Minutes Time, by any Person of common Understanding.

Secondly; The Scale of this *Barometer* is fixed independently of the Instrument itself; and is of one absolute and determinate Measure, arising from Nature, and not from the uncertain Fancy and Caprice of the Artist, as it necessarily does in other Constructions.

Thirdly; The two Fluids of *Air and Mercury* are here in immediate Contact, and always mutually sustain each other in the *most perfect Equilibre*; for the Tube being of a proper Size, there can be no Cohesion between it and the Mercury to obstruct the Motion of the latter; and there being no other possible impediment to its free Motion arising from the Construction, the Altitude of the Mercury must always vary with the minutest Variation in the Weight of the Atmosphere. Whereas in all *Mechanical and Compound Barometers*, the *Friction, Adhesion, &c.* arising from the Mechanism, Smallness of the Bore, and other Causes, are of such a Nature

as

as will not admit of their being removed or annihilated by any Means whatsoever.

Fourthly ; By the Use of the *Nonius* the Scale of this Barometer is enlarged *Ten Times*, or 3 Inches is thereby rendered equivalent to 30 Inches ; which is as great an Extension of the Scale as you have in the *Compound Sort* ; without encreasing the natural Error of the Instrument, which in all others is unavoidable.

Fifthly ; The Error from Heat and Cold, which naturally attends every Construction of a Barometer, is totally corrected in the *simple Barometer*, as we have shewn ; but in no other Sort can this be done, without immense Difficulty and great Expence, as any one may be convinced who will give himself the Trouble to peruse Mr. SAURIN's Discourse on this Subject in the *Memoires of the Royal Acad. of Sciences for the Year 1727*. And even there it will be found a Matter more of Speculation, than of Practicability.

Sixthly ; The *simple Barometer* is not in itself liable to be impaired, or out of Order, and when by Accident it becomes so, there is scarce any Trouble or Expence attends its Reparation ; but in all compound and mechanical Barometers, we experience the contrary in every Respect.*

These are some of the peculiar and most essential Properties of the *simple Barometer* properly rectified, and which cannot fail to give it the Preference with all judicious People. I do not say any Thing with regard to the Moderateness of the Purchase in Comparison of other Barometers, though this is an Argument that
may

* I take no Notice here of the *Portable Barometer* ; its Structure being every Way so absurd, as renders it unfit for Use even to the most Ignorant and Incurious.

may have some Weight with those whose Purfes are light, and who do not chufe to pay for having a good Instrument spoiled.

I could never have believed, had I not been too well convinced of it by Experience, in many Instances, that the Ingenuity of Men should be employed to pervert the Intentions of Nature, in *making that wrong* with a great deal of Art, Expence, and Difficulty, which ſhe has benignly *conſtructed right* with ſo much Simplicity, Perſpicuity, and Eaſe. But in no one Caſe is this abſurd Procedure ſo notorious as in that of Barometers. Had we, on the contrary, aſſiſted Nature, and rectified the Barometer originally with the *Nonius*, there would have been no Occaſion for HUGENIUS to have added a Column of Water to that of the Mercury, and much leſs of Mr. DE LA HIRE's third Column of another Liquor upon that. If the Tenth of an Inch be divided into 20 Parts by the *Nonius* (as it very well may) then will the Scale of 3 Inches be rendered equivalent to a Scale of 60 Inches, or *Five Feet* in Length, and the Weight of the Atmosphere be determined to the two hundredth Part of an Inch in the Height of the Mercury, which is a much greater Degree of Accuracy than the *Wheel-Barometer*, the *Diagonal-Barometer*, the *Horizontal Barometer*, &c. can pretend to, with all the Pomp and Vanity of ſuch preternatural Conſtructions.

But it will avail little to argue on this Head; the Judicious need it not, a Word to them is enough; the Injudicious will not regard it, ſay what you will; their Caſe is too much like that of the *Blind, who ſwallow many a Fly*, and rather deſerves Commiſeration than Reflection. However, that it may not be thought I decry other
Forms

Forms and Constructions of Barometers without giving Reasons for it, I shall lay before the Reader the Construction and Theory of the *Cartesian* BAROMETER, which is certainly the best of all the bad Sort.

This double Barometer consists of two Parts or Tubes, *viz.* one that holds the Mercury, and the other a smaller Tube with a tinged Liquor, *viz.* *Spirit of Wine*. These are both connected together, and communicate with each other. The first, which holds the Mercury, has a large *Cylindrical Part*, denoted by A B C D, hermetically sealed on the Top; this is joined to a recurved Tube E F G of a proper Length, to which, on the lower Part, is another Cylinder H I K L affixed, equal to that above in Diameter; upon the Top of this is a small Tube M N O, of a sufficient Length for the tinged Liquor to move in.

One Part of this compound Instrument is filled with Mercury, suppose from P in the Cylinder above, to Q in that below; and the coloured Spirit fills the other Part of this Cylinder from Q to K, and from thence to N in the small Tube. This represents the State of such a Barometer for some particular Weight of the Atmosphere.

But when this Weight of Air alters and becomes (suppose) lighter, then will the Mercury sink from P to R in the upper Cylinder, and rise through an equal Space from Q to T in the lower one, which will cause the tinged Spirit to rise into the small Tube, and to ascend therein from N to O.

Now in order to find what different Height of Mercury in the Common or Simple Barometer corres-

corresponds to this Difference NO in the Height of the Spirit, it must be considered that if in the first State of the Air, when the Spirit was at N , the Spirit were taken away, and just so much Mercury put into the Cylinder IK as would have the same effect of Pressure, then the Height of this Mercury QS will be to the Height of the Spirit QN as the Specific Gravity (g) of the Spirit is to the Specific Gravity of Mercury (G), that is $QS = \frac{g \times QN}{G}$.

Again, when the Spirit stands at O , and the Mercury at T , if instead of Spirit, an equivalent Pressure of Mercury were substituted; its Height $TV = \frac{g \times TO}{G}$. Hence PS will be the Height of the Mercury in the first Case; and RV will be the Height thereof in the latter; and therefore $PS - RV$ will be the Difference of the Altitude of the Mercury in the *Simple Barometer* corresponding to that of NO in the *Compound One*.

Hence we have $PS = PQ - \frac{g \times QN}{G}$, and $RV = RT - \frac{g \times TO}{G}$; and putting the Diameter of the equal Cylinders $= D$, and that of the small Spirit Tube $= d$, we have $D^2 : d^2 :: NO : QT = \frac{d^2 \times NO}{D^2} = PR$ also. But $RT = PQ - 2PR = PQ - \frac{2d^2 \times NO}{D^2}$. Whence $PS - RV = PQ - \frac{g \times QN}{G} - PQ + \frac{2d^2 \times NO}{D^2} + \frac{g \times TO}{G}$; that is $\frac{2d^2 \times NO}{D^2} =$

$$-\frac{g \times QN}{G} + \frac{g \times TO}{G} = PS - RV = A.$$

But $TO - QN = NO - QT = NO - \frac{d^2 \times NO}{D^2}$; therefore

$$\frac{2 d^2 \times NO}{D^2} + \frac{D^2 \times NO - d^2 \times NO}{G \times D^2} = A =$$

$$\frac{2 G - 1 \times d^2 \times + D^2 \times}{D^2 \times G}, \text{ putting } NO = x.$$

Whence, lastly, we have $D^2 \times G \times A = \frac{2 G - 1 \times d^2 \times + D^2 \times}{D^2 \times G}$. Therefore $A : x :: \frac{2 G - 1 \times d^2 + D^2}{G \times D^2}$.

Now in very cold Weather it is found by Experience, that the Specific Gravities of Mercury and Spirit of Wine are as 16 to 1; whence in that Case $2 G - 1 = 31$; and so $A : x :: \frac{31 d^2 + D^2}{16 D^2}$.

Lastly, if we put $D : d :: 10 : 1$; then $A : x :: 131 : 1600 :: 1 : 12,21$; or the *Scale of Variation* in the compound Barometer is a little more than 12 Times as large as that of the simple Barometer without a *Nonius*, if the Parts have the Measures here assigned.

In very hot Weather we have $G : g :: 16,5 : 1$; and so $A : x :: 132 : 1650 :: 1 : 12,5$. In the simple Barometer the greatest Scale of Variation is 3 Inches, in this compound one it will be therefore, in very cold Weather, 36,64; and in very hot Weather 37,5; the Difference of which is 0,86 or 86 *Hundredths of an Inch*. And this Expansion is all owing to the Rarefaction of the Spirit, that of the Mercury upon so large a Surface being quite insensible.

Upon this View of the Construction of a *Compound Barometer*, it will be easy to observe,
C how

how very improper it is for philosophical Uses; for unless the two Basons AD and IK are perfect CYLINDERS, and of an equal Diameter, the above Computation could not be made; nor any one at all, with these Basons of a bulbous or convex Surface, as is the usual Form of them. Therefore unless made as the above Theory directs (and that will be found difficult enough) they can be of use only for a common Indication of Weather, without being capable of any *Scale of Rectification*, to render them worthy the Regard of a *Virtuoso*.

All that has been hitherto said about Barometers has been with regard to their Use on Land only, where they may be fixed and immoveable; but when we consider their *Use at SEA* (and where perhaps it is most necessary, and consequently greatest of all) the Case becomes widely different, or rather quite contrary to the former; for the *Torricellian Barometer* can by no Means be used on board a Ship, by Reason of the great Agitation the Mercury is there subject to, and the Variety of Positions the Barometer must acquire from the Rowings of the Ship. But in the *Compound Barometer*, the Mercury being confined, as it were, by the coloured Liquor, its Motion is but small, and such as is but little liable to render the Instrument useless for observing the Changes of the Weather at Sea.

And because the critical Uses are not here required, therefore instead of *Cylinders*, the Basons AD and IK may be of a globular or bulbous Form, as represented at the Top by the Curve (*a p e*) by which Means the Surface of the Quicksilver will be larger, its perpendicular Motion less of Course; also the *Scale of Variation*

tion will, in this Case, become very large; and lastly, the Structure of such a MARINE BAROMETER would not be difficult or very expensive, and it might be so contrived, that the Mercury could not be spoiled or lost in case of an Accident, nor troublesome to repair when out of order, by any ingenious Hand on board the Ship.

There is no necessity of enlarging further on this Subject; every Commander of a Ship I believe must be convinced, that the *Marine Barometer*, invented by Dr. HOOKE many Years ago, is not so simple in its Nature, not of such immediate and ready Use, nor so easy to be repaired when out of Order, as one of the Form here proposed.

Of the THERMOMETER.

AS TO THERMOMETERS, Experience has taught us how extensive their Use is in the *Commercial Arts*, as well as in the more curious Researches of PHILOSOPHY. The *Chemist*, the *Brewer*, the *Distiller*, the *Gardener*, find them necessary on many Accounts; the *Physician* is often directed by them to form a better Judgment of the Case of his *feverish Patient*; the *valetudinary Gentleman* thereby observes all the different Temperatures of Air without Doors and within. And the *Virtuoso* applies it to all the Purposes of Meteorology and Philosophy.

As to the Fluid with which the *Thermometer* is filled, it is generally Quicksilver, because that will exhibit all Degrees of Heat till it comes to boil, and therefore is far more convenient for Chemical Purposes, and many others where great Degrees of Heat or Cold are to be expe-

fimented. But the *Botanical Thermometer* for the *Green-house* is commonly filled with a red Liquor; and the Tube of a larger Bore will suffice for such Degrees of Warmth as exotic Plants require.

The Forms and Sizes are many to answer different Designs, some are small, of a Pocket or portable Form for the Physician, &c. Some very large, to contain a great Number of Divisions for great Degrees of Heat. Some of a peculiar Form adapted to particular Occasions, as the *Brewer's Thermometer*, &c.

The Manner of dividing the Scale is arbitrary, and may, for private Use, be any you please; but, for public Use, Custom has made it necessary to have *Farenheit's* Method, such as you see in the Thermometer A M in the Plate (Fig. 1.) where the Scale of the Degrees of Heat are on the left Side of the Tube, and on the right Side is the Scale K L of 26 equal Parts for *rectifying the Barometer*, as before described.

As all Degrees of Heat and Cold are *relative* to each other, and have no Term or Limit of Beginning or Ending, so there is properly no absolute Point of Comparison in such a Scale, not even the *freezing Point* is fixed and determinate; though in this Scale it is placed at the 32d Division. The *Temperate Point*, or Limit between Heat and Cold, is as yet unsettled; though usually placed in this Scale at the 55th Degree. I think of nothing more necessary to be said of Thermometers here, but that unless they are very carefully made, and well adjusted by a *good Standard*, they will be of little Use or Certainty.

Of

Of the **HYGROMETER**.

AN **HYGROMETER** being that Instrument which is fitted for discovering the different Degrees of Moisture and Dryness in the Air in general, but particularly that in the different Rooms and Apartments of the House, cannot but be considered as extremely useful and necessary, and therefore it has a Place allowed it on the Top of the Plate (Fig. 1.) of the *Triple Weather-Glass*.

There are many Ways of making such an Instrument, some better than others; but as there would be no End in describing them, I shall content myself with recommending here, that which I judge to be the most natural and simple, *viz.* a Line of common *Hempen-cord*; for being twisted, as it imbibes more or less Moisture or aqueous Particles from the Air, it will become thicker, and more twisted; and, of Course, shorter; and in dry Weather it will untwist, and lengthen.

Hence it follows, that if one End of such a Line or Cord be fixed, and the other connected with a little System of Pullies, fixed upon a moveable Axis in a proper Manner, it will turn that Axis one way and the other, as it alters its Length by the Moisture and Dryness of the Air. Therefore if an Index, as P, be fixed on the other End of that Axis, it will be carried over the Divisions of the Semi-circle NBO, shewing the Degree of Moisture in one Quadrant NB, and of Dryness in the other BO. This Cord is the Length of the Frame on the Back Part; and at any Time the Index may be set to the upper

upper Point B, when there is occasion to rectify it.

As nothing can be more prejudicial to a Person's Health than a very moist or damp Air, so this Instrument may be looked upon as a *Nuncio* of Salubrity; for which Reason it is much to be valued and regarded. And those who will take Pains, and proper Care to regulate it (which is too often neglected) may find it not in vain. However it is not to be expected that the *Hygrometer* should be as perfect in its nature as the *Barometer* and *Thermometer*; because nothing is yet found to receive and part with the Particles of Moisture in an instantaneous or equable Manner. These Particles are quickly attracted by the Cord, but not so suddenly expelled by the action of Heat which occasions Dryness.

Having thus explained, and put together in one Frame, these three capital and important Instruments, which constitute an *universal METEOROSCOPE* or *Triple WEATHER-GLASS*; I know of nothing more that I can do to serve the Public in this Respect, but *furnishing them with the Instrument itself well made.*

N. B. Since these Sheets have been in the Press the Mercury has been higher than I ever remember to have seen it; for on *Jan. 29, 1766*, by carefully measuring the Altitude thereof with a *Nonius*, it was found to be 30,76 Inches, which gives the Height 30,665 equal to the Measure of the true Weight of the Atmosphere at that Time, by Rule in Page 11, and the *Scale of Rectification.*

APPENDIX.

A P P E N D I X.

I Think of but one Objection that the present Form of the Barometer I have here recommended, is liable to, and that is the Want of a large hollow Globe or Ball which has been usually blown upon the Top or close End of the Tube, whose Use was to receive the Air which might remain in the Tube after it was filled, and by giving it a great deal of Room to expand itself, prevent its obstructing the Rise of the Quicksilver as much as possible.

In answer to this, I can only say, that such a Bubble is but too plain an Argument that they who think it necessary, are not acquainted with the true and genuine Method of filling the Tube with Mercury, which leaves no Room to suspect any Remainder of Air that can have the least sensible effect on the Altitude of the Mercury in the Barometer.

But that the *Mathematical Reader* may have it easily in his Power to judge of this Matter, I shall here give a *New Solution* to that curious *Barometrical Problem* of the celebrated Mr. COTES,* and I think more direct and simple than any one I have yet seen. The Problem is this, *having given the Height of Mercury BD in the Tube which is equal to the Weight of the Atmosphere at a given Time, it is proposed to find the Deficiency CD from the Height occasioned by the Spring of a given Quantity of Air EF at the Top of the Tube.* Put $BD = a$, $DE = b$, $EF = c$, and $DC = x$; then because



the

* See his *Hydrostatical Lectures* Page 85, 86, &c.

the Spring S of the Air in EF is equal to that of the external Air $= BD = BC + CD$; and because the said Weight of the Atmosphere is also equal to the Column of Mercury BC and Spring (S) of the included Air, now expanded into the Space EC ; therefore we have $S = BD$; and $s = BD - CB = DC$. Hence it is $S : s :: BD : DC$.

But we have shewn elsewhere,* *That the Spring of the same Quantity of Air is reciprocally as the Space it possesses.* Therefore $S : s :: CE : FE$; and consequently we have $CE : FF :: BD : DC$, that is, $b + x : c :: a : x$, which gives $x^2 + bx = ac$; the Square compleated, and the Root extracted, gives $x = \sqrt{ac + \frac{b^2}{4}} - \frac{1}{2} b = DC$. Q. E. D.

Example; suppose $BD = a = 30$, $DE = b = 4$, and $EF = c = 0,025$; then $x = DC = 0,17$, the Deficiency from the true Altitude BD . The Space $CF = 4,17$ the half thereof is $2,085$, Hence suppose the Top of the Tube blown into the Form of a Cylinder, whose Length is $2,085$, and Diameter to that of the Tube as 10 to 1 ; then would its Capacity be 50 times that of CF , or equivalent to $208,5$ Inches of the Tube.

In this Case $b = 208,5$; and $x = DC$, will be found about $0,05$; and therefore such a Cylinder, or Globe equal to it, will prove a sufficient Reservoir for the *subreptitious Air* in Barometers, where no great Nicety is required. When $b = 0$, or *negative* ($-b$) the Value of x is found $= \sqrt{ac}$, or $x = \sqrt{ac + \frac{1}{4}b^2} + \frac{1}{2}b$.

* See Mathematical Institutes, Vol. II. Page 303, &c. in the General Magazine of Arts and Sciences.

F I N I S.